

Impact of Technical Noise on Supercontinuum Generation in Microstructure Fiber^{*}

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Abstract: The influence of the input laser technical noise on the noise of a generated supercontinuum is experimentally and numerically investigated. The supercontinuum technical noise is an amplified version of the input technical noise.

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The supercontinuum generated by ultrashort pulse propagation in a microstructure fiber (MF) has proven a useful tool for metrological and spectroscopic applications. However, the high relative intensity noise (RIN) on the supercontinuum can be a limitation to these applications. The RIN has two components: a broadband component due to fundamental noise sources [1] and a low-frequency component arising from the laser technical noise, *i.e.* mechanical noise sources. This paper specifically investigates the low-frequency technical noise, which is related to recent work on the sensitivity of the supercontinuum to the input pulse energy [2, 3]. Experimental data complemented with numerical simulations show that the fiber nonlinearities act to amplify the input laser technical noise by 20-30 dB.

The supercontinuum technical noise (RIN_{SC} , in dBc/Hz) can be expressed in terms of the input laser technical noise (RIN_{laser}) as

$$RIN_{SC}(\lambda) = 20 \log_{10} |k(\lambda, \Delta\lambda, P_0)| + RIN_{laser}(\lambda), \quad (1)$$

where λ is the center wavelength at pass bandwidth $\Delta\lambda$, P_0 is the input peak power and k^2 is the gain on the technical noise.

Figure 1 depicts the experiment. Input sech^2 pulses of 45 nm spectral width centered at 810 nm were generated from a Ti:sapphire laser. A variable quadratic phase distortion was imposed on the pulses by the use of a double-pass prism-pair before being injected into 15 cm of MF. The monochromator passed supercontinuum light centered at λ with bandwidth $\Delta\lambda=8$ nm, and the resulting photodiode voltage was analyzed with an electrical spectrum analyzer to determine the RIN. The gain was the difference between this RIN and the input laser RIN at low RF frequencies (180 kHz – 300 kHz).

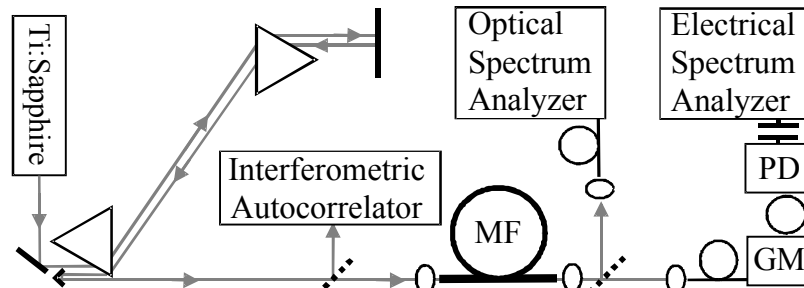


Fig. 1 The experiment to determine the supercontinuum technical noise. GM, grating-based monochromator; PD, photodiode.

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Pulse propagation was simulated to model the technical noise amplification. The input technical noise was simulated by a train of pulses with a Gaussian noise on the peak power of each pulse equivalent to the measured laser fluctuation of 0.4 %. The nonlinear Schrödinger equation was numerically solved using each of these pulses as the initial field. The resulting supercontinuum pulse train was spectrally filtered with a passband DI, and then used to compute the gain versus wavelength.

Both the experiment and simulation show a complicated dependence of gain on wavelength; for convenience only the median gain over a wavelength range of >20 dB normalized supercontinuum intensity is plotted below. As seen in Fig. 2, the gain increases with input power since the effects of the fiber nonlinearities increase with larger peak powers. The dependence of the gain on the initial pulse phase distortion is illustrated in Fig. 3. Unlike the broadband noise component [1], the technical noise gain is not dependent on the input pulse phase distortion.

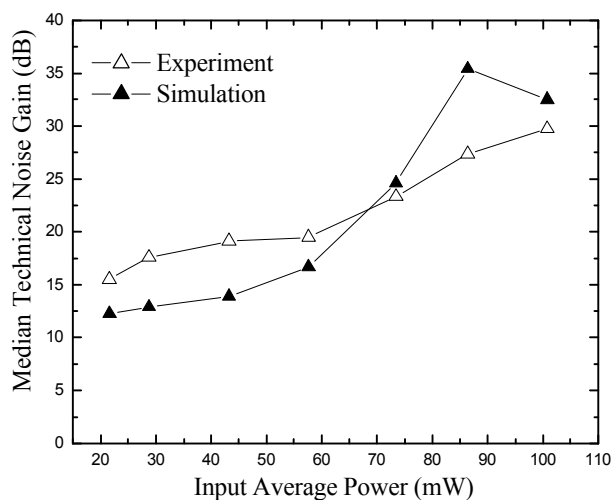


Fig. 2 The experimental and simulated technical noise gain versus input average power. The input quadratic phase distortion was -282 fs^2 .

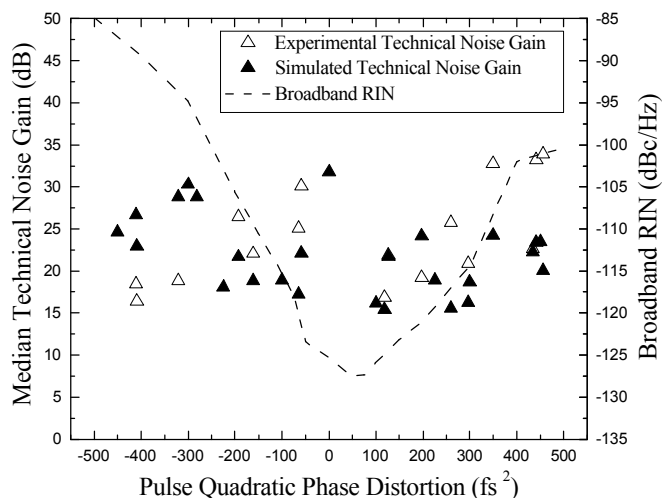


Fig. 3 The experimental and simulated noise as a function of input pulse phase distortion.

In conclusion, we have demonstrated both experimentally and numerically that fiber nonlinearities occurring during supercontinuum generation amplify the input technical noise. The technical noise gain is independent of the initial pulse chirp and increases with larger input peak powers.

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